Design and operation of a 1.5-km laser strainmeter installed in the KAGRA underground site

*Akito Araya[1], Akiteru Takamori[1], Wataru Morii[2], Kouseki Miyo[3], Masatake Ohashi[3]

1.ERI, Univ. Tokyo, 2.DPRI, Kyoto Univ., 3.ICRR, Univ. Tokyo

Laser interferometers are widely used for precise measurement such as experimental physics, engineering, and metrology. Laser strainmeters in geophysical observations are one of such applications that require high displacement resolution and long-term accuracy.
In Kamioka underground site (Gifu Prefecture in Japan), a 100-m-long laser strainmeter was constructed in 2003. It proved to be sensitive enough to detect Earth’s strain in a wide range of frequencies (seismic to geodetic time scale) with high resolution (~10^{-10} in strain) [1-3]. However, local disturbances by groundwater affected the strain measurement at very low frequencies [4]. A scaled-up interferometer is expected to improve the strain resolution by having a longer baseline and reduce local effects by spatial averaging.
A large-scale gravitational-wave detector, KAGRA, has been constructed in the new tunnel [5]. Along the KAGRA detector, a 1.5-km baseline laser interferometer has been installed for the purpose of geophysical strain observation. The laser strainmeter is formed by an asymmetric Michelson interferometer with two retro-reflectors each of which is installed in the vacuum chamber of each end. A frequency-doubled Nd:YAG laser with wavelength of 532 nm and frequency stability of ~10^{-13} is used as a light source. The optical path of the interferometer is kept below ~0.1 Pa in 400-mm-diameter vacuum tubes.
For long-term continuous observation with both KAGRA detector and the laser strainmeter, several kinds of sensors are arranged to monitor the environment along in the tunnel, and their data together with the ones from KAGRA and the strainmeter are recorded by a networked data acquisition system.
Scientific targets, design of the instrument, its construction and operation will be presented.

References

[1] S. Takemoto et al., A 100 m laser strainmeter system installed in a 1 km deep tunnel at Kamioka, Gifu, Japan, Journal of Geodynamics, 38, 477-488, 2004.
[2] S. Takemoto et al., A 100m laser strainmeter system in the Kamioka Mine, Japan, for precise observations of tidal strains, Journal of Geodynamics, 41, 23-29, 2006.
[3] A. Araya et al, Analyses of far-field coseismic crustal deformation observed by a new laser distance measurement system, Geophys. J. Int., 181, 127-140, 2010.
[4] A. Araya et al., Broadband observation with laser strainmeters and a strategy for high resolution long-term strain observation based on quantum standard, J. Geod. Soc. Japan, 53, 81-97, 2007.
[5] Y. Aso et al, Interferometer design of the KAGRA gravitational wave detector, Phys. Rev. D, 88, 043007, 2013.

Keywords: strainmeter, laser, crustal deformation, KAGRA, Kamioka, gravitational wave

©2016. Japan Geoscience Union. All Right Reserved.